REMARKS

Claims 1-20 are pending. Elected claims 10-13, as amended, remain for examination. Claims 1-9 and 14-20 stand withdrawn from consideration.

1. In response to oral restriction requirement a provisional election with traverse was made during a telephone conference with the Examiner on January 7, 2004, to prosecute the invention of Group II (i.e., claims 10-13) in this application.

2. The specification is amended in various places. First, in Paragraph 38 to correct the spelling of "remover" for element 41; see the next Paragraph 39 where it is properly spelled. (A minor self-evident addition change has been made in Paragraph 38.) Second, in Paragraph 52 to properly identify the constant current source/controller as "75" rather than "71" as originally presented. See Paragraph 54 where the proper legend 75 is used on page 37, line 2. Also see Fig. 3 where the legend 75 is used and where "71" is for the FB Controller. (A further minor change appears here also.) Finally, in Paragraph 78 the spelling of "trace" is corrected for the device for generating a

trace oxygen 42. See the previous Paragraph 77 for the name for element 42 on page 55, line 4.

3. Claims 10-13 were rejected under 35 U.S.C. 112, second paragraph, as indefinite. Eleven rejections were made. They are grouped below by claim and then by the various rejections for each claim.

3A. Claim 10

3A-1 Incomplete -not steps to actually measuring oxygen

Claim 10 is amended to recite a feeding step to feed the measurement gas to the oxygen sensor and a calculating step that calculates the oxygen concentration from the measured pump current.

3A-2 Question about oxygen concentration range

The Examiner requests clarification concerning the limitation "which corresponds to an oxygen concentration range of at least 2 ppm." This claim specifies that the electromotive force set voltage of the concentration detecting cell (13 in Fig. 1) is to be at a prescribed voltage of up to 240 V. The quoted term is an appositive to indicate that this voltage range is the voltage corresponding to an oxygen concentration range of at least

2 ppm. Support for this concept is found in the specification at Paragraphs [0024], [0018], [0021], [0045], [0046], and [0071]. From those passages, one can see that the proper voltage is "240 mV" (millivolts) and thus claim 10 has been corrected to recite "240 mV."

3A-3 Question about "ensuring followup of Nernst's formula"

The Examiner questions the limitation "ensuring followup of Nernst's formula". This expression is described in the six passages described in Section 3A-2 above. The expression is amended to read "ensuring the following of Nernst's formula" further to clarify this expression.

The Nernst's equation is discussed, for example, in U.S. Patent No. 4,857,164 at col. 6 thusly.

The oxygen concentration of the measuring gas in the diffusion chamber 36 is assumed at a predetermined concentration of 0.002 ppm at air ratio m is about = 1. By using the following Nernst's equation the calculation is carried out.

$$E_c = \frac{R \cdot T}{n \cdot F} \, en \left(\frac{P_{O2}}{P_{O2}'(= 0.002 \text{ ppm})} \right)$$

Wherein;
R: gas constant
T: absolute temperature
F: Faraday's constant
P_{O2}: oxygen concentration of measuring gas at outside of the oxygen sensing element
P_{O2}': oxygen concentration of measuring gas at inside the diffusion chamber

Namely, the mutual relationship between the electromotive force E_C of the oxygen concentration cell portion and the current amount of the pumping current I_P is calculated while assuming the oxygen concentration P_{O2} of the measuring gas in the diffusion chamber 36 to be a predetermined value of 0.002 ppm.

Thus the Nernst's equation permits the determination of the oxygen concentration from a measured electromotive force E_c.

3A-4 Question about "feeding oxygen necessary for achieving a set oxygen concentration"

The set oxygen concept is discussed at the end of Paragraph [0021]. There it is pointed out that when oxygen is necessary it can flow from the first air duct 12A.

EMF (electromotive force), which corresponds to an oxygen concentration in a measuring duct 19, is determined by the concentration detecting cell 13. If the oxygen concentration in the measuring duct 19 is lower than the

set concentration, then the oxygen quantity discharged from the measuring duct 19 to the first air duct 12A is determined by the current value of the oxygen discharge electrode 16.

On the other hand, in a case where the oxygen concentration in the measuring duct 19 is higher than the set concentration, the oxygen quantity discharged from the first air duct 12A to the measuring duct 19 is determined by the current value of the oxygen discharge electrode.

These controls are carried out by the feedback controller.

3A-5 Question whether "special oxygen feed air duct" should be the "first air duct"

Paragraph [0045] on pages 30 and 31 of the specification explains that "a special air duct" 12A is provided communicating with the open air (page 31, lines 12-13). Duct 12A is defined as "a first air duct" in Paragraph [0031] on page 22, line 3. Accordingly, claim 10 is amended to recite "first air duct" in place of the "special oxygen feed air duct."

3B. Claim 11

<u>3B-1 Antecedent support for "the oxygen remover"</u>

To overcome this rejection, the term "the oxygen remover" in the limitation beginning "measuring the oxygen concentration. . ." is amended to "an oxygen remover." Such an oxygen remover is illustrated as 41 in Fig. 2 and described in Paragraph [0038].

<u>3B-2 Antecedent support for first & second oxygen pump currents</u>

To provide antecedent basis for "the first measured oxygen pump current" and "the second measured pump current," claim 11 is amended in prior sections to define "a <u>first</u> oxygen pump current" and "a <u>second</u> oxygen pump current" which are measured in these prior sections.

<u>3B-3 Question about calculating difference between two pump currents</u>

The Examiner's comment about calculating the differences between the two pump values is correct. As explained in Section 3B-2 above, one pump value is described as "first" to indicated it is the <u>measurement gas</u> and the other as "second" to indicate that it is the gas <u>with the oxygen removed</u>. Applicants submit that these two

terms identify the two pump values being measured. As to a "chronology," the order of making the measurements is of no consequence - - as long as the two measurements are made so the correct concentration value can be obtained.

3B-4 Question about claiming one or two oxygen sensors

The embodiment having only one oxygen sensor is shown in Figs. 1-3 and an embodiment where there are two oxygen sensors is shown in Figs. 4 and 5. Claim 11 relates to the embodiment where one sensor is used to obtain the first and second current measurements. For the case of using two sensors, dependent claim 13 defines how each of the sensors is used to obtain the two pump current measurements. Claim 11 is generic because it calls for using "at least one oxygen sensor" for measuring the oxygen content in the measurement gas. Claim 11 is also amended to shorten and simplify the last step of calculating the oxygen concentration from the two measured oxygen pump currents.

3C. Claim 12

3C-1 Question about the terms "or not" or "the same"

To avoid any possible confusion caused by the use of the two quoted terms, claim 12 is amended to describe the

switching mechanism for the measurement gas as providing two pathways to the oxygen sensor:

> wherein the measurement gas is fed to the oxygen sensor by a switching mechanism that permits either (a) the flow of the measuring gas directly to the oxygen sensor or (b) the flow first to the oxygen remover and then to the oxygen sensor.

The Examiner is correct that "applicant is specifying an embodiment where there is one sensor and the measurement gas can be switched between going through the oxygen remover and not going through the oxygen remover." Applicants say this amendment to claim 12 spells out such a concept in a straight forward manner.

<u>3D. Claim 13</u>

<u>3D-1 Suggestion to state two separate oxygen sensors are used</u>

The Examiner contends claim 13 has the same confusing chronology problems as claim 11. See Section 3B-3 above explaining that to measure the oxygen concentration, one needs to measure the entire measurement gas in an oxygen sensor (referred to as the "first oxygen pump current") and to measure also in an oxygen sensor the measurement gas

without any oxygen present (referred to as the "second oxygen pump current") to establish the background signal given by the other gases in the measurement gas. When that background value is subtracted from the entire oxygen containing measurement gas value, one obtains the oxygen concentration. These two pump currents can be obtained using one oxygen sensor (Fig. 2) or by using two oxygen sensors (Fig. 4, sensor 51 and 52). The two-sensor embodiment is claimed in claim 13. With two sensors it is no longer necessary to have each sensor make two current determinations. Each sensor can just make one determination of the two pump currents. As discussed above in Section 3B-3, the chronology of when the measurements are made is not critical - one needs only to have both pump currents measured (preferably at about the same time) so the difference can be calculated to determine the oxygen concentration. See Paragraph [0062].

Furthermore, it is possible to make a continuous measurement by correcting the delay in the oxygen remover by the CPU (see Paragraph [0041]) when two sensors are used. In this respect, please see the statement on Paragraph [0063] of the present specification. It is for

the indicated reason why two sensors are used in one measuring apparatus.

Accordingly, review and withdrawal of these Section 112 rejections are requested.

4. Claim 10 was rejected under 35 U.S.C. 103(a) as unpatentable over Usami et al. (USP 4,902,400) in view of Logothetis et al. (High-Temperature Oxygen Sensors Based on Electrochemical Oxygen Pumping, pp. 136-154). This rejection is traversed.

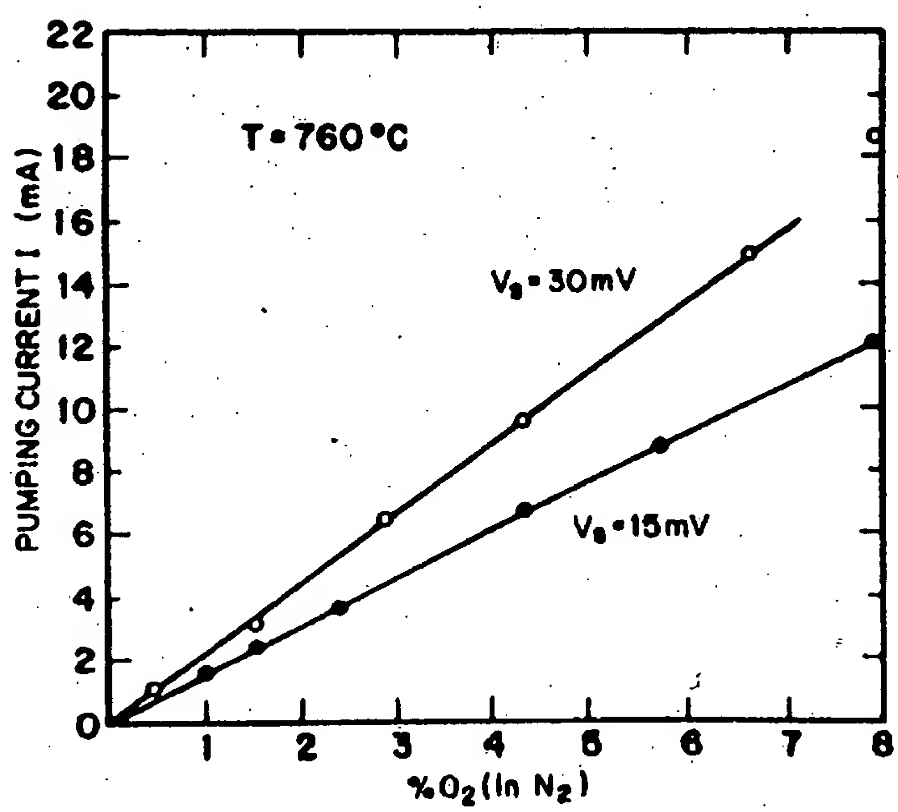
Usami et al. '400 discloses a method of measuring the oxygen concentration of a measurement gas using an oxygen sensor. In the discussion of the Prior Art in col. 1, lines 31-36, the use of these sensors is indicated thusly:

> Such electrochemically operating gas sensors utilizing a solid electrolyte are used, for example, as oxygen sensors for determining the oxygen concentration in exhaust gases emitted from an internal combustion engine of a motor vehicle, or from industrial furnaces, boilers and similar equipment.

As the Examiner notes:

> ...Usami does not clearly lay out how this combination of concentration detection cell and pump cell operate (with particular attention to the use of the feedback control between the concentration detection cell and the pump cell and the use of the current from the pump cell as a measure of the oxygen concentration).

Logothetis et al. is a paper entitled "High-Temperature Oxygen Sensors Based on Electrochemical Oxygen-Pumping"; pages 145-148 and Fig. 7 on electrochemical cells (known in the art as "double-cells") and how they are operated are cited specifically. One sees in the lower part of Fig. 7, copied below



the pumping current for various oxygen levels. The amount of oxygen in the graph above is from about 0.5% to 8%.

Logothetis et al. are employees of the Ford Motor Company and one would assume they are working on sensors for automobile engines. Logothetis et al. are not teaching how to make a trace oxygen sensor in the ppm ranges and thus there can be no proper

combination of Usami et al. '400 with Logothetis et al. to obtain the method of measuring trace oxygen concentrations of claim 10.

There is no suggestion from these references of the characteristic effect that a high output linearity of the trace oxygen concentration region can be attained by limiting the set value of feedback control to an electromotive force within a range ensuring the following of Nernst's formula, as discussed in Paragraph [0046] of the present specification. Accordingly, review and withdrawal of this rejection are requested.

5. Applicants thank the Examiner for indicating that claims 11-13 would be allowable if rewritten or amended to overcome the rejection(s) under 35 U.S.C. 112, second paragraph, above. For the reasons previously discussed in Section 3, applicants submit that claims 11-13 are now in condition for allowance.

Applicants respectfully submit that all the elected claims 10-13 are now in condition for allowance. Accordingly, the Examiner is requested to issue a Notice of Allowability for these claims and to also examine the nonelected claims and especially claims 1-9, drawn to trace oxygen measuring apparatus, which is the unique apparatus used in these process claims.

Should the Examiner deem that any further action by the applicants would be desirable for placing this application in even better condition for issue, the Examiner is requested to telephone applicants' undersigned representative at the number listed below.

April 13, 2004
Date

Respectfully submitted,
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